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NOTES ON THE RATE OF GROWTH OF THE CHINESE POPULATION*

BY A. J. JAFFE
U. S. Bureau of the Census

THE population of China today is officially estimated by the Chinese Government as some 450 millions (11, p. 6). Various estimates have been made of the probable historical growth of the population and these have been summarized by Chen (3, p. 5) in the following table:

YEAR	ESTIMATED POPULATION (in thousands)
A. D. 2	59 500
742-56	52 900
1098-1100	43 000
1573-1620	60 600
1933-	400 000

Whether the above really represents the approximately true rate of growth of the Chinese population is difficult to say. We can only

* The views expressed here are those of the author and do not necessarily reflect any opinions held by the U. S. Bureau of the Census. The author wishes to thank Mr. Henry J. Dubester of the Census-Library Project of the Library of Congress for his extensive bibliographical assistance.

be sure that the population sometime in the past—say at the beginning of the Christian Era—must have been considerably smaller than it is at present. Chen makes the point that changes in the size of the population have probably been cyclical, or at least have fluctuated. In favorable years there may have been considerable increases; with the advent of famine, flood, or epidemic diseases, the death rate might have been increased to the point where any population gains of previous years were nullified. Indeed, the figures presented above represent what he calls the peak points of various cycles. "From the beginning of the Christian Era down to the present, 5 cycles have been found in Chinese population, each reaching the highest point as shown in . . . [the table above]."

With reference to present times he believes that the peak of the fifth cycle has perhaps been reached and that actual population decline may be setting in. For the last century or so he thinks that China's population increase has been negligible (see also reference 13).

Chen feels that the fifth cycle should not really be compared with the preceding four cycles. During the earlier periods there was no evidence of a trend in population growth, but simply the cycles around a horizontal line. He says (3, p. 5):

> "By nature of the population data, the four cycles should be separated from the fifth one, chiefly because the former purported to include only portions of the nation's population and the latter its total. The linking-together of the two series of cycles, as is usually done by the scholars in China and abroad, causes confusion. The very fact that the peaks of the first four cycles fluctuated within a narrow range between 43,000,000 and 60,000,000 in a period longer than sixteen hundred years indicates that, in the past, China's population moved only in a zigzag fashion, mainly in relation to peace and order; whereas, beginning with the fifth cycle, a different course of events may be shown, since the figures purport to include the total population of the country."

However, he offers no suggestions as to the facts which lead to this remarkable increase of perhaps five-fold during the last 300 years.

DATA AVAILABLE FOR STUDY OF THE PRESENT POPULATION

Altogether twelve "censuses" which have been taken in various parts of China, during the last fifteen years, were found by the writer.[1]

[1] Although demographic data are available for the Chinese population living in Formosa, it was felt that the experiences of this group are not necessarily similar to those of the peoples living in China proper. The main difference, of

These have all been small enumerations and the populations covered range from 20,000 to a maximum of 600,000 persons. Some of these have been complete enumerations of designated areas, and some have been sample studies. Unquestionably they are of variable reliability.

For all of these twelve enumerations the age distributions for both sexes combined are available; for seven of them the distributions by age and sex are available.

Vital statistics were obtained from the volume, *An Experiment in the Registration of Vital Statistics in China* (6), and from the volume by Chen (3).

AGE DISTRIBUTION

In Fig. 1 is presented the age distributions of the various populations in the following intervals: 0 to 14 years, 15 to 34 years, 35 to 54 years, and 55 years of age and over. Instead of drawing a line to represent the percentage for a specific age group, a band has been drawn showing the upper and lower limits as obtained from the different censuses. Comparison of this distribution with that for the United States leaves no doubt but that the Chinese population is younger than that of the United States. No Chinese enumeration produced as low a figure for the percentage under age 15 as exists in the United States, nor as high a figure as that of the United States for the population 55 years of age and over. In the two intermediate age groups the percentages registered in the United States age distribution are the maximum reached by any Chinese enumeration (see also Table 1).

This high proportion of young people, of course, suggests a high birth rate, and accordingly, let us examine the available vital statistics.

PRESENT BIRTH AND DEATH RATES

Various studies have been made of the vital statistics of the nation. As early as 1902 the International Settlement at Shanghai began an attempt to collect death statistics. Since then numerous other compilations have been made including the excellent one jointly conducted by the Scripps Foundation for Research in Population Problems, and Nanking University.

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course, stems from the fact that Formosa had a politically stable government under the Japanese; this factor of the degree of political stability unquestionably has an important bearing on the demographic problems of the Chinese living in China.

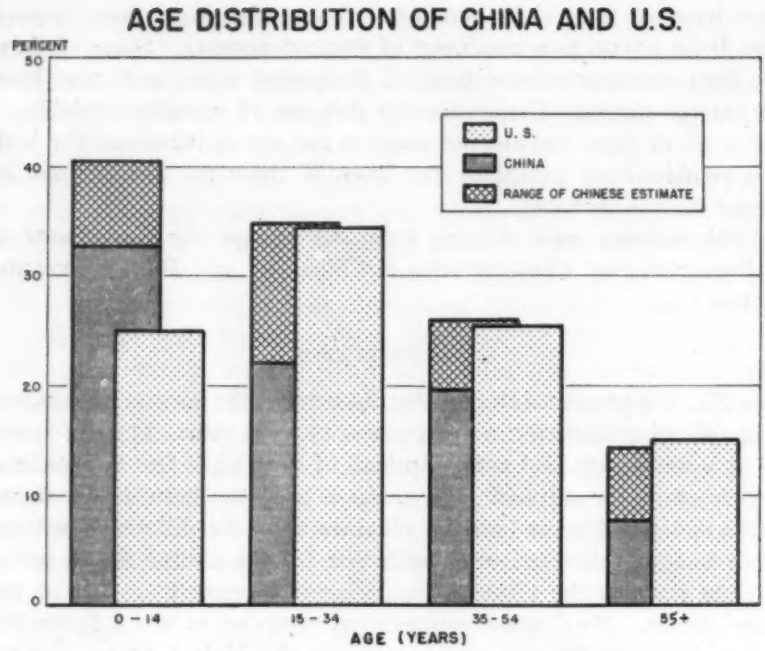

FIG. 1. PERCENTAGE AGE DISTRIBUTION OF CHINA AND THE UNITED STATES

Chen, in reviewing the reported crude birth rates, lists 17 rates "as being relatively more reliable." The range of these rates was from a low of 12.2 for Shanghai in 1932 to a high of 58.4 in Yen Shan, Hopei, 1923. On the basis of these various reported rates, Chen (3, p. 29) estimates a national birth rate for China of 38 per 1,000 population.

In the opinion of the writer a rate of 38 is probably too low. As far as can be learned from studying the various age distributions available, 38 would appear to be a minimum rather than average figure. The crude birth rates as estimated from these age data range from a low of about 36 to a high of perhaps over 50.[2]

[2] The minimum crude birth rate as estimated from the age distribution for Chang Lu in Hopei is 26 per 1,000 population. Chen, in commenting on the census of Chang Lu, suggests that this enumeration may have been rather deficient. "This census seems to have been taken on the basis of the *de jure* population, but its definition was not strictly adhered to; hence there was a good deal of confusion regarding the total population of the *hsien*." The next lowest birth rate was observed in Ting Hsien, in Hopei province, a birth rate of 36 per 1,000 population (see Table 2).

TABLE 1

Percentage age distribution, China

		UNDER 15 YEARS	15 TO 34 YEARS	35 TO 54 YEARS	55 YEARS AND OVER	TOTAL
Kiang Ying	(1932)	40.2	31.2	19.8	8.8	100.0
Chu Yung	(1933)	40.7	31.1	20.6	7.6	100.0
Kiang Ning	(1933)	38.8	30.5	21.7	9.0	100.0
Ting Hsien	(1934)	33.3	30.2	23.9	12.6	100.0
Chang Lu	(1935)	32.7	34.7	23.0	9.6	100.0
Lan Hsi	(1936)	36.3	32.8	21.3	9.6	100.0
Cheng Kung	(1938)	34.8	28.4	24.9	11.9	100.0
Szechwan	(1942)	37.8	22.0	25.9	14.3	100.0
Kunming Lake Region	(1942)	33.7	33.3	23.7	9.3	100.0
North China	(1930)	33.7	32.2	23.2	10.9	100.0
South China	(1930)	36.5	34.2	21.0	8.3	100.0
Nanking	(1939)	34.5	27.8	25.1	12.6	100.0
United States	(1940)	25.0	34.4	25.7	14.9	100.0

Sources: Chen (3), Appendix Table 7, for all but the last three areas of China. Data for North and South China from Chiao (4). Data for Nanking from Bates (1).

With regard to deaths, Chen reports rates for 17 areas which are "comparatively more reasonable." These range from a low of 13 per 1,000 population in Tsing Yuan, Shansi in 1926-1928, to a high of 37.1 in Yen Shan, Hopei in 1923. On the basis of these, Chen (3, p. 32) estimated the national death rate as 33 (1934).

How accurate these estimates are is difficult to say. The one thought which appears pertinent is that most likely both the birth and death rates reported above refer to relatively peaceful time periods. During the periods of catastrophe—flood, famine, disease, war—the death rate obviously would increase considerably, and the birth rate would probably fall. Hence, the death rate, if calculated over a long period of time so as to include the proper proportion of droughts, floods, and epidemics, would undoubtedly be higher than the average of 33 estimated by Chen. Incidentally it is claimed that China has had an average of 49 droughts somewhere within its boundaries every 100 years, and an average of 48 floods every 100 years. In addition, epidemics may break out on an average of every 5 years. Thus, it would

TABLE 2
*Estimated vital rates, China**

		ASSUMING MORTALITY SCHEDULES OF:		
		CHINESE LIFE TABLE	INDIAN LIFE TABLE 1921-30	INDIAN LIFE TABLE 1901-10
Gross reproduction rates				
Hsiao Chi, Kiangyin	(21,864)	2.78	2.97	3.20
North China		2.35	2.52	2.72
South China		2.40	2.57	2.77
Szechwan				
Penghsien Hsien	(368,868)	3.46	3.71	4.00
Shwanglin Hsien	(152,458)	3.19	3.41	3.68
Chungning Hsien	(94,331)	3.14	3.36	3.63
Ting Hsien		2.58	2.76	2.97
Nanking		1.93	2.07	2.22
Cheng Kung		2.67	2.86	3.08
Net reproduction rates				
Hsiao Chi, Kiangyin		1.34	1.28	1.19
North China		1.14	1.09	1.01
South China		1.16	1.11	1.03
Szechwan				
Penghsien Hsien		1.68	1.60	1.49
Shwanglin Hsien		1.54	1.47	1.37
Chungning Hsien		1.52	1.45	1.35
Ting Hsien		1.25	1.19	1.10
Nanking		.94	.89	.83
Cheng Kung		1.29	1.24	1.15
Crude birth rates (as estimated from the age composition)				
Nanking	(7,161)	28	30	33
North China	(28,740)	37	40	43
South China	(36,644)	37	40	43
Szechwan	(619,471)	39	42	45
Ting Hsien	(439,259)	36	39	42
Kiang Ying	(21,864)	45	48	52
Chu Yung	(279,455)	44	47	51
King Ning	(562,063)	39	42	45
Chang Lu	(227,801)	26	28	30
Lan Hsi	(276,468)	40	43	46
Cheng Kung	(71,223)	38	41	44
Kunming Lake Region	(507,216)	38	41	44

Sources: Hsiao Chi, Chiao, Thompson, and Chen (6); North and South China, Chiao (4); Szechwan, *Statistical Abstract of the Republic of China*, 1945 (11); Ting Hsien, Lee (8); Nanking, Bates (1); all other areas, Chen (3).

* See footnote next page.

appear that some catastrophe hits some part of the country every year on the average (3, p. 37).

The crude rate of natural increase, according to Chen's calculations, should thus be some 5 per 1,000 population per year—in relatively peaceful times.

GROSS AND NET REPRODUCTION RATES

Obviously any figure purporting to represent all of China is an estimate whose degree of reliability is probably open to serious question. Accordingly, the attempt was made here to analyze the various available age distributions in an effort to determine the likely range within which the "true" figure for China may lie. Since the number of births of necessity must be estimated from the reported number of young children, two methodological questions are immediately raised: (a) what, if any, is the degree of underenumeration of these children, and (b) what survivorship rates should be used in converting the reported number of children into numbers of live births.

For the moment let us table the first question and discuss the latter. In attempting to convert the reported numbers under 5 years of age into numbers of live births, three life table values were used: (a) that for China as reported by Seifert (10), (b) India, 1921-1930, and (c) India, 1901-1910. The female life expectancies as shown by these three life tables are respectively 34.63, 26.56, and 23.31.

As mentioned previously, distributions by age and sex were available for seven areas in China; one of these presented data for its three component counties, making a total of nine age and sex distributions actually available.

If it is assumed that the Chinese life table with a life expectancy of about 35 years is applicable, then the computed net reproduction rates range from a low of 1.14 in the sample of localities in North China to a high of 1.68 in Penghsien. Use of the Indian life table of 1921-30, with a life expectancy of about 27 years, produces a range from 1.09 to

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* None of these rates have been corrected for the probable underreporting of children under 5 years of age. Further, information was not available bearing on the point as to whether the concept of age as utilized in these Chinese enumerations was similar to that used in the western world. Since some of the age distributions designated an age of "under 1 year" it is assumed that the concept of age for census purposes, was intended to be similar to that in the western world.

1.60, and the earlier Indian life table, from 1.01 to 1.49. In other words, the minimum net reproduction rate is unity. The only exception is the city of Nanking which seems to have a rate of below unity.

Turning to the gross reproduction rate, a range from a low of 2.35 to a maximum of 4.00 is noted, again depending in part on the life tables used in converting the number of children under 5 years of age into the number of live births (see Table 2).

Census enumerations all over the world have invariably failed to include all the children under 5 years of age. Accordingly, it appears likely that the reported numbers of children in these various Chinese censuses also are below the true number. Both the gross and net reproduction rates, should be increased—perhaps by as much as 10 per cent. With such a correction the minimum observed net reproduction rate then becomes around 1.10.

In summary then, the following can be noted:

(a) Given reasonably normal and peaceful conditions—i.e., with a death rate of between 30 and 40 per 1,000 population—the Chinese population perhaps will grow at the rate of at least 10 per cent per generation.

(b) What the actual rate of growth has been in the past has been largely determined by the death rate. Presumably population changes have fluctuated widely and have been cyclical rather than following any particular trend.

(c) The birth rate is actually so high that any diminution in the death rate would immediately mean a vast population increase. For example, if the minimum observed gross reproduction rate of 2.35 is converted into a net reproduction rate on the basis of a life table having an expectancy of 41 years, (such as is found among the non-white population in the Union of South Africa—1935 to 1937), a net rate of 1.32 is obtained; in other words the population would increase by one-third in a generation.

CONCLUSIONS

The factors repeatedly found to be associated with high fertility throughout the world, are also found in China—namely, an agricultural population, very poor, and highly illiterate. One factor in the Chinese scene which is not so universally found, is the high proportion of the adult population which is married. Data from five censuses reveal a minimum of 70 per cent of the females (15 years of age and over)

married, to a maximum of 93 per cent. Even the minimum figure is well above that for the United States. Similarly, larger proportions of the adult males are married. In addition, age at marriage—particularly for the girls—is generally younger in China than in the United States.

Is it possible for the Chinese population to increase? At present there appears to be between ½ and ¾ acre of cultivated land per person as compared with 3 acres per person in the United States. These figures in themselves reveal the "pressure on the land." In addition, China, unlike the United States, has neither great manufacturing industries nor widespread commercial activities to help support the masses. Some Chinese economists think that the amount of cultivated land and agricultural production eventually can be materially increased.[3] If the people should remain satisfied with their present plane of living, then the population can increase in the same proportion as agricultural production; if the population is kept at its present level, then the plane of living can increase as more land is brought under cultivation, and productivity increased.

In the past the attitudes of the people toward population growth apparently were expressed by the following statement (3, p. 72) attributed to Confucius, "To die without offspring is one of the three gravest unfilial acts." Even the thought of limiting population growth was not to be condoned.[4]

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[3] That increases in the amount of cultivated land and agricultural productivity are possible is suggested by the progress already claimed. The National Conservation Commission, through its establishment of irrigation works, claims to have extended already "the land area for cultivation." In addition it is claimed (11, p. 12) that "since the government started to enforce the policy of promoting agricultural production, area and production of crops have had steady increase in . . . 15 provinces."

Buck suggests that "a well organized program administered by properly qualified technical experts, with international experience and knowledge in the subject matter of each problem will enable China rapidly to improve her agriculture, to raise the standard of living of her farmers, and to enhance the well being of the nation as a whole." A series of 16 points are suggested to implement this program (2, pp. 21-22).

[4] This is not to say that voluntary means of population control have never been practiced in China. Infanticide, abortion, and eunuchism, apparently were, in the past, and perhaps now, are being practiced to some extent. In addition, various contraceptive recipes have been utilized, although it is not known to what extent nor how effectively. Modern birth control methods have begun to make their appearance in China, as witnessed by the opening of clinics in Shanghai and Peiping, and the sale of contraceptives in the modern drug stores. (See Norman E. Himes, *Medical History of Contraception*, The Williams and Wilkins Co., Baltimore, 1936, pp. 105-113).

Today, by contrast, there is a Committee for the Study of Population Policies which has deviated considerably in its thinking from the time honored customs of the past. With reference to the quantity of population this committee concluded (3, p. 76):

> "Facing poverty, ignorance, and the low living standards of the masses, the country should not and cannot encourage unconditional and universal increase of population. Increase should occur only where the individuals, as parents, are physically fit and mentally sound, where the families are able to give the children proper care and training, and where the social surroundings are favorable. The parents, after careful consideration of the interest of the family and of the community, may decide for themselves as to the proper number of children they should bring up. In addition, the number of children may also vary with the skill and income of the parents, as well as with the folkways and social wealth of the community. Thus viewed, some individuals may have children, others not; some communities may have population increase, others not. A differential rate of increase will, therefore, have to be worked out between individuals, classes, and communities in the interests of all the parties concerned."

Perhaps the attitudes of the masses are slowly changing in the direction of lowered birth rates and lessened desire for population increase. Such changed attitudes accompanied by political stability, land reform measures, and the growth of manufacturing activity will permit China to realize her potentialities.

REFERENCES

1. Bates, M. S. The Nanking Population, Employment, Earnings, and Expenditures. (Survey conducted on behalf of the Nanking International Relief Committee, Winter-Spring, 1939.)
2. Buck, J. L. Land Utilization in China. University of Chicago Press, *Chicago*, 1937.
3. Chen, Ta. Population in Modern China. University of Chicago Press, *Chicago*, 1946.
4. Chiao, C. M. Rural population and vital statistics for selected areas of China, 1929-31. *Chinese Economic Journal*, Vol. XIV, Nos. 3 and 4. (Survey of 22 localities in 11 provinces.)
5. ————. A study of the Chinese population. *Milbank Memorial Fund Quarterly Bulletin*, Vol. 11, pp. 325 ff., 1933. Vol. 12, pp. 85-96, and 171-183, 1934.
6. ————, W. S. Thompson and D. T. Chen. An Experiment in the Registration of Vital Statistics in China (*Oxford, Ohio:* Scripps Foundation for Research in Population Problems, 1938.)

7. LEE, FRANKLIN C. H. An analysis of Chinese rural population. *Chinese Social and Political Science Review*, Vol. 19, pp. 22 ff., 1935-36. (House-to-house census in Ting Hsien Experiment Area by the Social Survey Department of the Chinese National Association of the Mass Education Movement: 1930.)
8. ————. Problems of technique as revealed in population census of Ting Hsien. *Social Science Quarterly* (Tsing Hua University), Vol. II, No. 3, April, 1937. (Available at Orientalia, Library of Congress.) (In Chinese.)
9. NOTESTEIN, FRANK W. and CHI-MING CHIAO. "Population," Chapter XIII, in J. L. BUCK, Land Utilization in China.
10. SEIFERT, HARRY E. Life tables for Chinese farmers. *Milbank Memorial Fund Quarterly*, Vol. 13, No. 3. pp. 223-236, July, 1935.
11. STATISTICAL ABSTRACT OF THE REPUBLIC OF CHINA, 1945. Directorate of Statistics, National Government, *Chungking, China.*
12. THOMPSON, WARREN S. Population prospects for China and Southeastern Asia. *Annals*, Vol. 237, pp. 72-79, Jan. 1945.
13. WILLCOX, WALTER F. The Population of China and Its Modern Increase. *Studies in American Demography*, Cornell University Press, *Ithaca, N. Y.*, 1940.

SEX DIFFERENCES IN PHYSICAL ABILITIES*

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IN AN earlier report from the Adolescent Growth Study, Espenschade (2) has shown that sex differences in various track events become greatly accentuated at adolescence. The sudden increase in the superiority of boys is due to the fact that girls, on the average, reach a peak at about 13 years and thereafter improve only slightly, while boys show a very rapid improvement for several years after the age of 13.

This can be illustrated in several ways. At 13 years 3 months (close to the average age of menarche) girls in this group threw an indoor baseball for an average distance of 71 feet. Three years later their average throw was only slightly greater, 73 feet. In the same interval, the performance of boys improved from 116 to 145 feet.

In the standing broad jump, girls on the average jumped 94 per cent as far as boys, at the earlier age; and only 71 per cent as far, at the later age. In the vertical jump their average performance (distance between standing reach and jumping reach) improved 16 per cent, while the performance of boys improved 33 per cent. In the 50-yard dash, while boys made effective gains in speed, girls ran *less* rapidly at the end than at the beginning of the three-year period.

In examining these results, an anthropologist disposed to interpret behavior in terms of social factors might point out that our contemporary culture promotes and approves more vigorous activities for boys than for girls at adolescence. A high valuation is placed on the competitive excellence of boys in sports involving running and jumping, while a girl who can compete with boys in such sports is assigned the not wholly complementary name of "tomboy." The traits which determine popularity and leadership in girls are related to social skills, appearance, and social-status-maintaining attitudes rather than to effectiveness in physical activities. Hence girls do not have the incentive

* A more extended treatment of this material will be included in Chapters 3, 4, and 6 of a forthcoming volume on *Motor Performance and Growth* (3).

to put forth maximum effort in physical ability tests, and moreover are not interested in exercising and developing those physical powers that a boy must achieve if he is to live up to the current model of a "real" boy.

It may then be urged that the obtained sex differences are quite inevitably an outcome of cultural bias, and that a reversal would occur in a different social system, in which, for example, women hunt and work in the fields while men maintain status through more leisurely types of activity. Anthropologists have indeed reported on societies in which the male and female roles as we know them are very greatly modified, but their reports unfortunately lack quantitative appraisal of the physical characteristics with which we are here concerned.

The present report provides evidence on a sex difference in physical ability which the writer will seek to interpret in primarily biological terms. At the present time it is not possible to rest such an interpretation upon crucial experimental evidence, but it will be shown that the descriptive findings point very clearly in that direction. The cases consist of 89 boys and 87 girls from the schools of Oakland, California; for this normal sampling of public-school children, cumulative records are available, at half-year intervals from age 11 to age 17.5 years.

SEX DIFFERENCES IN GROWTH CURVES

Figs. 1 and 2 present growth curves, in kilograms, for four measures of muscular strength (static dynamometric strength).[1] From age 11 to 13, the sex differences are not great. In Left Grip the girls are about 1 S. D. inferior (in terms of the variability of the boys' scores); in Right Grip they are from .7 to 1 S. D. inferior; in Pulling Strength they are from .4 to .6 S. D. inferior, and in Thrusting Strength girls are fully equal to boys. At age 13, however, an upward inflection occurs in the case of the boys, while the girls tend to level off in their performance. The increasing divergence between the two sexes is clearly seen in Fig. 1, in which the finer solid lines are extrapolations, indicating the average course of growth, for each sex, if the rate from 11 to 13 years were to be maintained for the following years.

[1] The technique of measurement is described in reference (3). The test of Pulling Strength involves an opposed pull of the two hands, away from the midline of the body, when the dynamometer is held at chest level. Thrusting Strength is tested in the same position, and involves an inward compressing movement of the two hands.

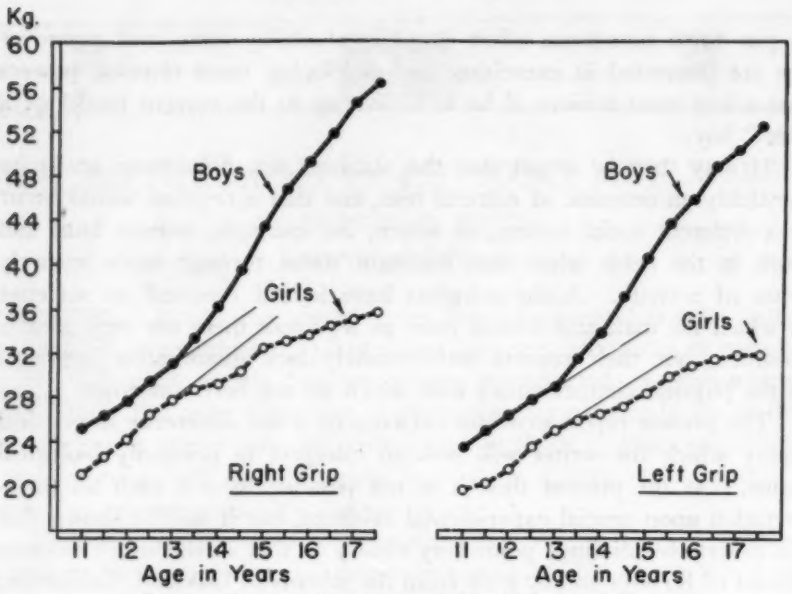

FIG. 1. GROWTH CURVES FOR RIGHT AND LEFT GRIP

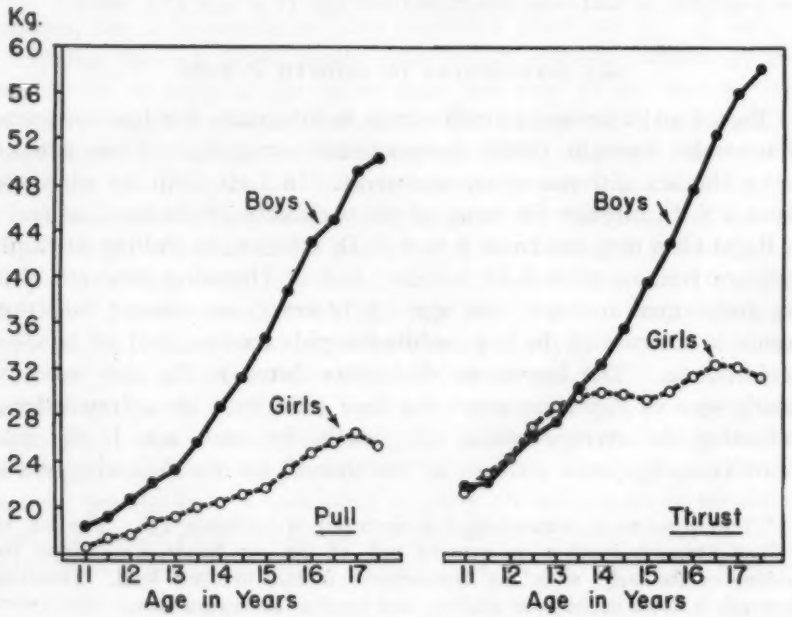

FIG. 2. GROWTH CURVES FOR PULL AND THRUST

Whereas the boys veer upward after the age of 13, the girls lag behind in each function; this lag is so great that by 17.5 years the difference between the means for boys and girls has become approximately 3 S. D., in terms of the variability of the boys' scores, and approximately 4 S. D. in terms of the variability of girls.

Figs. 3 and 4 present a more detailed comparison, showing the per-

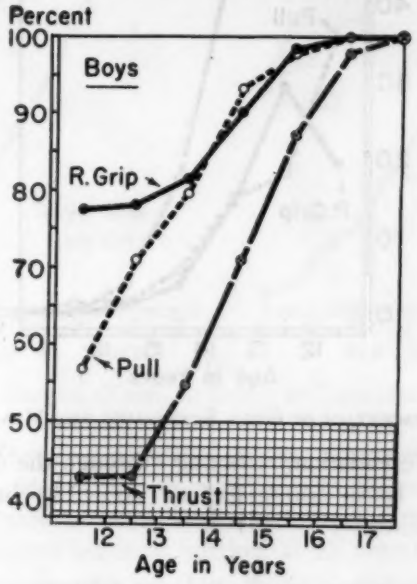

FIG. 3. PERCENTAGE OF BOYS SURPASSING THE MEAN OF GIRLS

centage of cases of each sex surpassing the average score of the other sex at successive ages. The ascending curves in the first of these figures indicate a rapid increase (after age 13) in the proportion of boys excelling the average girl. The curves in the second figure indicate a precipitous drop in the proportion of girls whose performance reaches that of the average boy. We may note that Gripping and Pulling Strength present a similar developmental record with regard to sex differences, but that Thursting Strength follows a separate course, with a smaller degree of sex difference in the early and middle years of adolescence. In each of the three functions, however, the sex distributions overlap so little, after the age of 16, that practically no girls reach the boys' means, and practically no boys fall below the girls' averages. It is the writer's contention that these curves are essentially

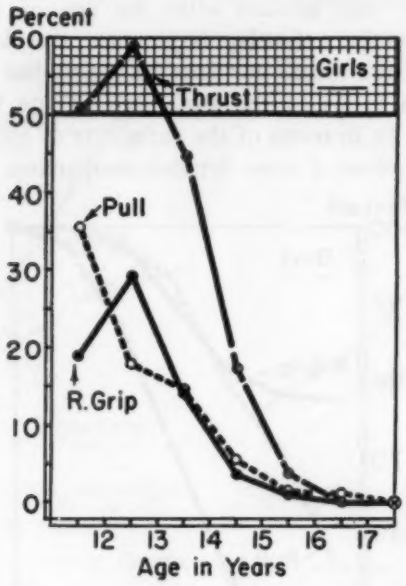

FIG. 4. PERCENTAGE OF GIRLS SURPASSING THE MEAN OF BOYS

curves of sex differentiation, reflecting (through the data of functional tests) the more basic differentiations occurring in anatomical and physiological features.

SEX DIFFERENCES IN RELATIVE GROWTH CURVES

Another approach to the analysis of this problem is through the comparison of boys and girls in *relative* growth curves, in which the average at a given age is taken as a percentage of the terminal average for our series, at age 17.5 years. This technique is particularly useful if we wish to examine the comparative growth patterns for different characteristics. In Fig. 5 it may be noted that within each sex the relative pattern of growth for Right and Left Grip is substantially the same; so nearly similar, in fact, that separate curves cannot readily be drawn. This is true even though the right hand is used more than the left, and is stronger, in absolute values. At the age of 11, girls have on the average reached about 60 per cent of the Gripping Strength which they will possess at age 17.5; at this age boys have reached only 45 per cent of their terminal value, and will not attain the 60 per cent level until about the age of 14.

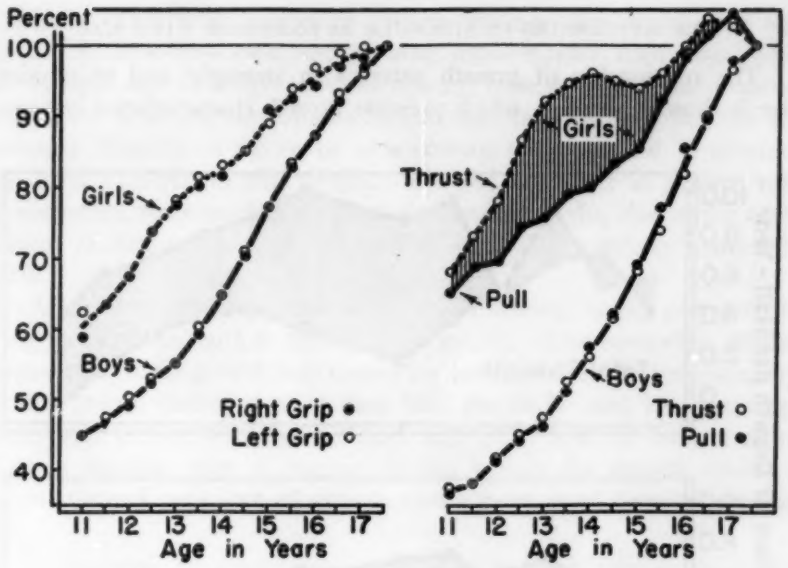

FIG. 5. GROWTH CURVES IN TERMS OF TERMINAL STATUS

Pulling and Thrusting Strength present a somewhat different picture, for whereas equivalence in pattern is to be noted in these two functions in the case of boys, they are sharply differentiated among girls. The differences are most marked at 13 years, when boys have reached about 45 per cent of their terminal strength, both in Pull and Thrust, while girls have reached about 75 per cent of their terminal strength in Pull and over 90 per cent in Thrusting Strength.

Between 11 and 13.5 years, the Thrust test is the only one in which girls are able to compete with boys on equal terms (see Fig. 2). Their good performance in this function indicates that increments must have been relatively large at pre-adolescent ages. But this greater velocity of growth is not maintained, and in fact is followed by a more rapid tapering-off than is true of the other functions. Except for a smaller secondary rise at 16 years, girls attain almost their adult level in Thrusting Strength as early as age 13.5 or 14. While this pattern of sex difference could not be predicted from any available facts concerning the muscular anatomy involved, it seems impossible to explain it as due to procedural or psychological factors. We may regard the facts presented in Fig. 5 as an illustration of the specific nature of biological sex differences.

SEX DIFFERENCES IN STRENGTH AS COMPARED WITH SIZE

The relationship of growth patterns in strength[2] and in physical size is shown in Fig. 6, which presents growth characteristics in terms

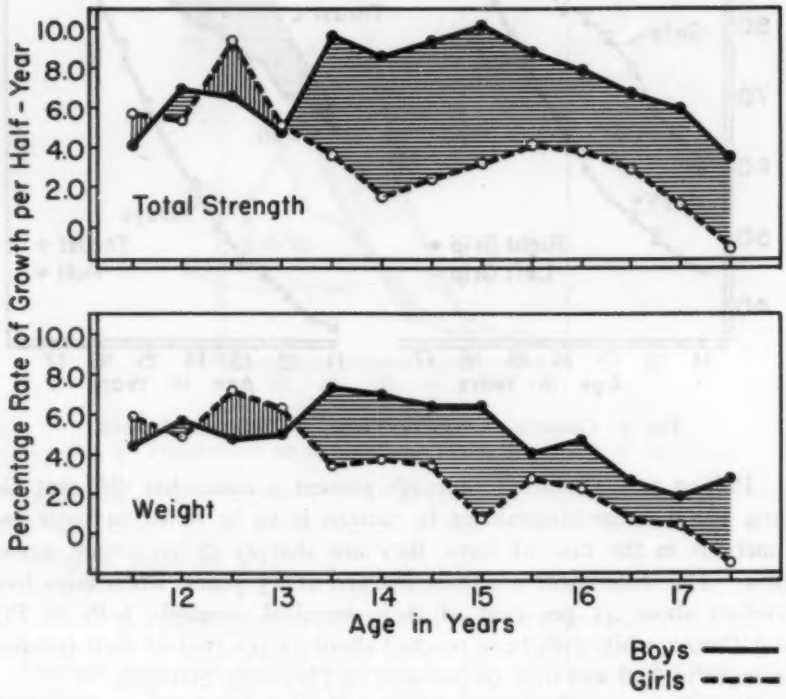

FIG. 6. RELATIVE INCREMENTS IN THE GROWTH OF STRENGTH AND WEIGHT

of relative increments. These are calculated by the Minot (4) method, in which the gain over a given interval of time is taken as a percentage of the level at the beginning of that interval.

Increment curves, being based on differences, are commonly less smooth and regular than cumulative growth curves, but Fig. 6 reveals, for each sex, a general pattern which is similar in both strength and weight. The curves are also similar in the actual magnitude of growth changes for strength and weight.

[2] Total Strength, including Right Grip, Left Grip, Pulling Strength, and Thrusting Strength.

Girls attain their maximum growth rate, on the average, at age 12.5. At this time girls are growing more rapidly than boys, both in strength and in weight. After age 13, however, the relative increments for boys are consistently larger, and this accounts for the increasing disparity of the sexes, as adulthood is approached, in absolute measures of strength and weight. The sex difference in growth rate is somewhat more marked in strength than in weight, due to the component of non-muscular "dead weight" which is relatively greater in girls.

Among boys the peak rate of growth is attained in the period from 13.5 to 15 years, with a decline after age 15. The somewhat flattish appearance of the growth rate curves for boys is due to the heterogeneity of the group, including as it does both the early- and late-maturing. Individual curves, both among boys and girls, tend to show a more distinct pattern, with a sharper decline before the growth spurt, a rapid rise to a peak rate of growth, and a more rapid terminal decline.

GROWTH IN STRENGTH AS RELATED TO THE MENARCHE

The similarity of growth patterns for strength and for weight is emphasized if we compare these patterns for early- and late-maturing individuals within one sex. This is illustrated in Table 1, which pre-

TABLE 1

Growth in strength (Right Grip) and in weight, in terms of percentage of terminal status (early- and late-maturing girls)

AGE	EARLY-MATURING		LATE-MATURING	
	Strength	Weight	Strength	Weight
11.5	79.8	72.0	64.3	60.1
12.5	89.1	85.8	69.3	67.1
13.5	93.3	86.4	76.8	75.9
14.5	95.6	91.5	86.5	80.4
15.5	97.0	98.5	93.5	92.6
16.5	99.5	102.4	97.7	97.4
17.5	100.0	100.0	100.0	100.0

sents, at yearly intervals, the average strength and weight for 16 girls who reached the menarche before twelve years (at an average

age of 11.7) and 16 girls who reached the menarche after fourteen years (at an average age of 14.8). In order to facilitate comparison, the averages for strength and weight have been transformed into percentages of the terminal average at age 17.5. It may be noted that at 12.5 years early-maturing girls exceed 85 per cent of their terminal strength and weight, whereas late-maturing girls do not reach this level until more than two years later. Thus it would appear that, similarly for strength and weight, growth patterns are closely tied to biological factors in the basic rhythm of sexual maturing. Regardless of the chronological age at which the menarche falls, the peak rate of growth in strength occurs shortly before this physiological reference point.

PUBERAL CHANGES IN RELATIVE VARIABILITY

Characteristic sex differences are also to be seen in measures of variability. Fig. 7 compares boys and girls in coefficients of variation

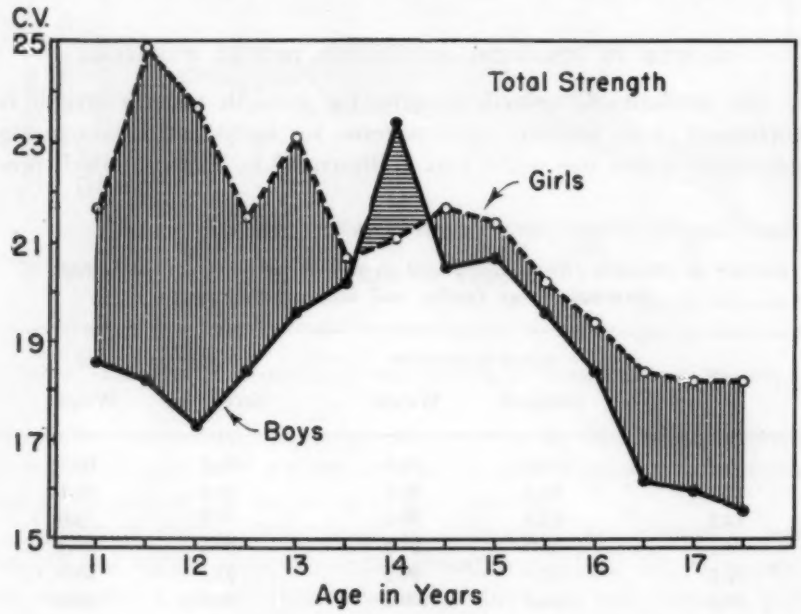

FIG. 7. COEFFICIENTS OF VARIATION BY AGE

(100 S. D./Mean). The figure demonstrates a cyclical change in relative variability, with a rise which occurs earlier in girls than in

boys, and with a sharp recession in each sex after the maximum is reached. Such a result would be expected if the puberal growth spurt occurs earlier in some individuals than in others. Its appearance in those first to mature would produce an increasing heterogeneity of scores, followed by a return toward more normal variability as an increasing majority of cases complete their growth spurt. Comparison of Figs. 5 and 6 indicates that in each sex the peak of relative variability is reached about a year earlier than the peak for the average rate of growth. This is also to be expected, for by the time the average rate of growth has reached its maximum, the spread of scores due to deviations in maturing is beginning to be reduced. The principal point to note, however, is that the maximum variability is attained by boys two and a half years later than in the case of girls, in general accord with the differences in the timing of sexual maturity among boys and girls.

SEX DIFFERENCES IN DEXTRALITY

Less easy to explain is another sex difference, involving the relative strength of Right and Left Grip. As compared with girls, the greater interest of boys in mechanical activities and in sports which involve catching and throwing might be assumed to provide greater opportunity for lateral specialization of strength, involving a greater division of labor between the two hands and a relatively greater amount of practice for the right hand. Other things being equal, we might then expect that the average dextrality index (Right Grip divided by Left Grip) would be greater in the case of boys than of girls. Table 2 presents

TABLE 2

Dextrality indices, by age and sex

AGE	OAKLAND SERIES		LONDON SERIES	
	Boys	Girls	Boys	Girls
12.5	106.1	112.2	105.9	112.3
13.5	106.0	110.0	106.8	110.1
14.5	106.7	111.9	104.9	108.0
15.5	106.9	110.9	105.4	108.0
16.5	106.2	110.2	105.1	110.1
Mean	106.4	111.2	105.6	109.7

a comparison of dextrality indices from the present study and also from a series of dynamometric strength records reported from the Galton Laboratory in London (1, 5). This table shows that at each age, and in both the Oakland and London samples, the right grip is approximately 6 per cent stronger than the left among boys, and approximately 12 per cent stronger among girls. In terms of the standard deviation of Right Grip scores, boys were on the average stronger in the Right Grip to the extent of .37 S. D.; girls were on the average stronger in Right Grip to the extent of .57 S. D. As in other aspects of strength, the results for girls are somewhat more variable from year to year, but their greater right-hand dominance seems well established.[3]

The greater degree of dextral predominance among girls is in harmony with the fact that the incidence of right-handedness is somewhat greater among girls than among boys. Is this responsible for the sex difference in dextrality indices? To answer this question it is necessary to conduct a separate analysis for groups classified on the basis of handedness. In the present sample we can make a classification into three groups on the basis of examinations which were repeated semi-annually over a period of 18 months:

Group I was made up of individuals who were consistently right-dominant both by tests of handedness and eyedness.

Group II consisted of crossed dextrals (right-handed and left-eyed); some of the individuals included in this group were unstable or inconsistent in the eyedness tests, but all were consistently right-handed.

Group III consisted of individuals who were either definitely left-handed, or possessed sinistral peculiarities such as unstable handedness preference, or dextro-sinistrality (writing with the right hand, but using the left in other unimanual activities).

Table 3 shows the mean dextrality index for each of these groups. For greater reliability, the index was computed not from a single examination, but on the basis of averages for three semi-annual tests, in the middle period of the study.

It will be noted that in each group the obtained means are higher for girls than for boys; in Group I, the sex difference is significant at the 6 per cent level; in Group II, at the 7 per cent level; and for all groups combined, at the 1 per cent level ($t = 3.4$). Among the boys

[3] It should be noted that the London sample, being cross-sectional, involves a different selection of cases at each age level, but with results almost as consistent as in the Oakland study.

TABLE 3

Dextrality indices in three laterality groups

GROUP	BOYS			GIRLS		
	N	Mean	S. D.	N	Mean	S. D.
I	53	109.5	9.4	44	113.5	11.9
II	22	106.6	7.7	29	112.6	13.0
III	11	100.2	9.2	10	112.9	10.1

the more strongly right-lateral individuals have somewhat higher dextrality indices; the degree of right-hand predominance varies in the three groups about as would be expected, except that in the "sinistral" and "dextro-sinistral" Group III, the average index fails to fall below 100. Among girls the Group III cases are approximately as right-handed in strength as the cases classified in Group I. The two most markedly left-handed girls had dextrality indices of 103 and 110 respectively.

Here, then, we have another specific sex difference in strength. Far from being attributable to environmental factors, the difference is in an opposed direction to that which might be expected as a result of sex differences in the use of the hands. We can only conclude that in this, as in the other aspects of strength which have been discussed, the sex difference rests upon a biological basis.

SUMMARY

1. From cumulative records of the development of strength among boys and girls in adolescence, it was shown that sex differences in static dynamometric strength are relatively small up to the age of 13. Beyond this age, differences rapidly increase, due to (a) an increased growth rate among boys and (b) a diminished growth rate among girls.

2. After the age of 16 the distributions in strength for the two sexes overlap so little that practically no girls reach the average performance level of boys, and nearly all of the boys are superior to the average of girls.

3. When the development of strength was analyzed in terms of relative growth (percentage of terminal status), it was found that

within each sex the pattern of growth was approximately identical for Right and Left Grip; but in these functions girls reached approximately 60 per cent of their terminal status at 11 years, while boys reached only about 45 per cent of their terminal status at that age.

4. Among boys, relative growth patterns for Pulling and Thrusting Strength were identical, but among girls these functions were sharply differentiated, Thrusting Strength being more mature in the earlier years and with a more rapid approach toward adult levels. The differences in relative status are most marked at 13 years, when boys have reached about 45 per cent of their terminal strength both in Pull and Thrust, while girls have reached about 75 per cent of their terminal strength in Pull and 90 per cent in Thrust.

5. During the early part of the puberal growth spurt, increases in variability are more rapid than increases in average scores, as shown by the fact that the coefficient of variation becomes larger at this time. Among boys and girls, relative variability changes with age in a characteristic timing which is different for the two sexes.

6. As shown by relative increment curves, the growth pattern for strength is similar to that for weight, and with similar differences between the sexes. In both strength and weight the girls in this group attained their maximum rate of growth at about the age of 12.5 years. Among boys the peak rate of growth is attained between 13.5 and 15 years.

7. The relationship of growth in strength to growth in weight, and their common dependence upon factors in sexual maturing, were shown, among girls, through a comparison of early- and late-maturing individuals.

8. In an analysis of the relative strength of Right and Left Grip, girls exhibited a differentiation in the two measurements greater than that found for boys. The greater dextrality of girls, in terms of strength scores, was not found to be due to their greater incidence of right-handedness, for similar or greater differences existed in groups which were homogeneous as to laterality.

9. Average sex differences in static dynamometric strength do not yield to explanation in terms of interest, use, or other psychological or environmental factors, and may be assumed to rest primarily upon a biological basis. It is not denied that the differences normally obtained may be altered by differential practice and training.

REFERENCES

1. ELDERTON, E. and M. MOUL. Growth curves of certain characters in women and the interrelationship of these characters. *Annals of Eugen.*, 1928, 3, 277-336.
2. ESPENSCHADE, A. Motor Performance in Adolescence. *Monog. Soc. Res. Child Develop.*, 1940, 5, No. 1. Pp. viii + 126.
3. JONES, H. E. Motor Performance and Growth. (To be published in 1947.)
4. MINOT, C. S. The Problem of Age, Growth and Death. *New York:* Putnam's, 1908. Pp. 280.
5. RUGER, H. A. and B. STOESSIGER. On the growth curves of certain characters in man (males). *Annals of Eugen.*, Cambridge, 1927, 2, 76-110.